A break from pain! Interruption management in the context of pain

RUNNING HEAD: INTERRUPTION MANAGEMENT IN PAIN

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Abstract

Activity interruptions, namely temporary suspensions of an ongoing task with the intention to resume it later, are common in pain. First, pain is a threat signal that urges us to interrupt ongoing activities in order to manage the pain and its cause. Second, activity interruptions are used in chronic pain management. However, activity interruptions by pain may carry costs for activity performance. These costs have recently started to be systematically investigated. We review the evidence on the consequences of activity interruptions by pain for the performance of the interrupted activity. Further, inspired by literature on interruptions from other research fields, we suggest ways to improve interruption management in the field of pain, and provide a future research agenda.

Keywords

Chronic pain, interruption management, activity pacing

Pain is an evolutionary signal conveying the message that a threat may harm our body [1]. As a salient stimulus, pain enters our attention even when we are engaged in other activities [1,2] and, in so doing, it urges us to suspend these ongoing activities in order to perform actions that protect our body integrity and relieve pain [1,3]. Therefore, activity interruptions by pain, that is, *temporary suspensions of an ongoing activity in response to pain, but with the intention to return to and resume the interrupted activity later* [4], are quite common.

Interrupting ongoing activities in response to pain has an obvious adaptive value, as it allows us to engage in protective actions that help us to escape from pain and to promote recovery and pain relief. At the same time, though, the interrupted activities urge their completion [1]. Studies from the field of human factors and ergonomics, where task interruptions have been extensively studied, show that interruptions increase stress, frustration, time pressure and effort invested in the task [5,6], whereas they also have negative effects on performance indices such as task accuracy and reaction times (cf. [7]). When the pain is acute and it is in one's interest to prioritize the prevention of (further) injury, such negative consequences may be of trivial importance. However, when pain is persistent and does not signify an actual injury or threat, activity interruptions may become maladaptive and contribute to chronic pain disability [4]. People with persistent pain problems who often interrupt their ongoing activities in the context of pain, that is, in a context where pain is experienced or anticipated, may experience performance impairments and negative emotions as a consequence of such interruptions. The question is: how can we best balance the costs and benefits of activity interruptions in the context of pain in order to optimize the functioning of people with persistent pain problems?

In the present article, we will propose ways to manage interruptions in the context of pain. First, we will briefly present how activity interruptions by pain have been studied, and discuss how this approach was influenced by the task interruption literature from outside the pain field. Second, we will review the evidence on the consequences of interruptions by pain for activity performance, with a special focus on experimental studies. Third, we will take a closer look at the clinical use of interruptions as part of a therapeutic technique called “activity pacing”. Fourth, we will make suggestions on how to improve interruption management in the context of pain, inspired by the task interruption literature from other research fields. Finally, we will discuss avenues for future research on activity interruptions by pain.

Defining activity interruptions in the context of pain

There exists a large body of research on the “interruptive function of pain”, that is, on the propensity of pain to grab attention and to interfere with ongoing activities [1]. The negative effects of chronic pain on various cognitive functions have been consistently shown [8–17] and specific recommendations as to how to improve cognitive functioning in chronic pain have been made [18]. Experimental research generally confirms that pain impairs the performance of concurrent tasks (i.e., tasks performed whilst feeling pain [19–28]) as well as of subsequent tasks (i.e., tasks that one switches to after a task performed under painful conditions [29]). Notwithstanding, these situations are not equivalent to the temporary suspension of a task before it is completed [30].

Research on the temporary suspension of a task in the context of pain has only recently begun. That research is strongly informed by the advances in the task interruption literature from the fields of human factors, ergonomics and computer-human interaction. Inspired by theoretical models from these fields [7,31–33], we proposed an analysis of the events taking place when an ongoing activity is interrupted by pain [4]. According to this analysis, the person is performing an activity in service of a (usually, pain-irrelevant) goal when pain occurs. Acting as the “interruption cue", pain indicates the possible need to interrupt the ongoing activity. During the so-called "interruption lag", i.e. the interval between the occurrence of pain and the disengagement from the ongoing activity, the person has the opportunity to prepare for the upcoming interruption [31,34]. This preparation might involve "wrapping up" the ongoing activity and/or encoding on memory the intention to resume the interrupted activity as well as information that will later help to resume the task [31,34]. Subsequently, the person disengages from the ongoing activity in order to do something else, usually with the aim to alleviate pain. When the time to resume the interrupted activity arrives, the person must retrieve from memory the intention to resume as well as the information about the state of the activity [34,35], in order to be able to resume the interrupted activity with success. Importantly, activity interruptions in the context of pain can differ in many respects, such as their duration (which may be preset or not, short or long, etc.) or the type of activity that takes place during the interruption (for example, rest or stretching exercises) [4]. Such factors are thought to moderate the consequences of the interruption, as is known from research on task interruptions outside the field of pain [7]. Unfortunately, systematic research on the potential moderating effects of such factors is lacking. However, the effects of activity interruptions by pain on activity performance have recently attracted scientific attention. We review the findings of this research in the next section.

Taking breaks in the context of pain: Consequences of interruptions

In the past years, several studies emerged investigating how, and how well, people perform activities when these are interrupted by pain. A series of studies have focused on interruption effects on what could be broadly described as the *pattern* of activity performance, that is, the way in which people perform their activities when these are interrupted in the context of pain. Okun and colleagues [36] showed that well-functioning people with chronic pain, who experienced interruptions of their work-related goals during the day, tended to resume these goals and continue working on them outside working hours. This was especially the case when interruptions left them feeling frustrated and disappointed. In other words, people with persistent pain problems tended to change their working pattern, or the way they distributed their time to various activities throughout the day, in order to achieve their (work-related) goals and thus maintain their functioning [36].

To our knowledge, the study of Okun et al. [36] is the only one to date to have investigated pain-related activity interruptions in a sample of people with chronic pain. However, the effects of activity interruptions by pain on the pattern of activity performance have been investigated in experiments with healthy volunteers and experimentally induced pain. One such experiment showed that the effects of activity interruptions by pain may vary depending on modulating factors such as pain catastrophizing [37]. In this study, participants engaged in an open-ended task, during which they either received a brief painful electrocutaneous stimulus followed by a 2-minute interruption consisting of a blank screen (i.e., no task during the interruption), or continued with no pain and no interruption. Results showed that participants who were interrupted by pain spent less time on the open-ended task, but only if they scored relatively high on pain catastrophizing. In contrast, individuals with low levels of pain catastrophizing spent more time on the task when they were interrupted compared to when they were not interrupted [37]. The modulating effect of pain catastrophizing was not confirmed in a later experiment [38]. In this study, participants performed a goal-directed joystick task, during which they occasionally received either brief painful electrocutaneous stimuli or non-painful (and non-aversive) auditory stimuli, followed by an interruption. During the interruption, participants performed a different and, crucially, open-ended task. Results showed a similar task performance pattern, in terms of time spent on interruptions and on the task as a whole (both of which were determined by the participant), irrespective of whether participants received a painful or a non-painful interruption cue [38].

Besides the pattern of activity performance, a series of controlled lab experiments have focused on the effects upon the *quality of performance,* as expressed by accuracy and reaction times [39,40]. In these studies, healthy participants performed an ongoing task that required them to carry out a sequence of steps (to perform a series of joystick movements [39] or to answer a series of questions [40] in a specific order). Such tasks require one to constantly keep track of their position in the sequence of steps in order to perform well (cf. [41]). Occasionally, participants received either a painful electrocutaneous stimulus or a non-painful vibrotactile stimulus, followed by the suspension of the ongoing task and the initiation of an unrelated activity (categorization of cards [39] or typing of codes [40]). After some time on this interruption activity, during which no painful (or non-painful) stimuli were administered, the interrupted task started again. In order to resume the interrupted task correctly, participants were required to remember the point in the sequence of steps that they were supposed to continue with.

As expected, participants responded slower [39] and less accurately [39,40] when they resumed the task immediately after an interruption, compared to when they were in the flow of the task. What is more, the lower accuracy regarded specifically the memory about where to pick up the task in the series of steps, but not the memory about the content of the task [40]. Counter to expectation, however, pain was not a worse interruption cue than non-pain, indicating that the contingency of the break might not be of utmost importance for the consequences of that break, at least with regards to the quality of performance in the interrupted activity immediately after the break.

In sum, the studies reviewed here indicate that activity interruptions by pain have negative consequences for the resumption and performance of the interrupted activity. Task accuracy and speed were shown to be impaired immediately after an interruption by pain, compared to when the person is in the flow of the task [39,40]. These findings are in line with a large body of task interruption research from outside the field of pain, which generally shows that interruptions impair performance (e.g., [7,34,41–56]), at least as long as the interrupted task is not too boring, simple, or repetitive [57]. In addition, experiencing interruptions because of pain appears to have an effect on the way that activities are being scheduled throughout the day [36], though this may not differ from experiencing interruptions due to non-pain [38].

All in all, activity interruptions by pain appear to be as impairing as activity interruptions by non-painful stimuli [38–40]. It is yet unclear why that is the case. Possibly some methodological characteristics of the experiments masked or overruled potential differences between pain and non-pain conditions. For example, in several of the experiments reviewed here [38–40], interruptions were imposed by the experimenter, thus leaving to participants no control over the exact moment of initiating the interruption or over the duration of the interruption lag, i.e. the preparation period before disengaging from the task. Outside the laboratory, however, people usually have a degree of control over whether and when to suspend their activities, also in the context of pain (see next section on activity pacing). In addition, experimental studies such as the ones reviewed here utilize experimentally induced pain that is brief and, at best, only moderately threatening. As such, it differs from the experience of chronic pain (and, possibly, even from the experience of acute clinical pain), which interferes more with patients' activities, pursuit of valued goals, and, eventually, their identity [58]. Apart from the quality of the pain, activity interruptions in the context of chronic pain may also have a different motivational value for patients, who are often taking a break in search of pain relief.

Nevertheless, controlled experimental studies allow the manipulation of interesting variables and the accurate measurement of target outcomes, thus allowing the establishment of causal relationships. Further, experimental studies that investigate psychological processes and mechanisms can facilitate the development of clinical interventions as well as the in-depth understanding and improvement of existing therapeutic practices (see, for example, how experimental research on extinction learning has contributed to the understanding of exposure treatment for anxiety disorders [59]). Ideally, clinical and experimental studies on activity interruptions in the context of pain will complement each other, and will facilitate the improvement of clinical applications of interruptions, such as activity pacing.

Interruptions in the service of pain management: The case of activity pacing

Activity interruptions are used in (chronic) pain management in activity pacing, a technique popular with both patients [60] and therapists [61,62]. Perhaps due to its popularity, intuitive character, and the fact that it cuts across clinical professions, activity pacing and its positive effects were being taken for granted for a long time, without having been thoroughly investigated [63]. Recently, however, there has been a wave of scientific interest in activity pacing. In the context of this recent interest, activity pacing has received clear definitions, which were missing for years. Specifically, it has been defined as a "*self-management strategy whereby individuals [...] balance time spent on activity and rest for the purpose of achieving increased function*" ([64], p. 409), or, similarly, as "*the regulation of activity level and/or rate in the service of an adaptive goal* […]" ([65], p. 465).

Although activity pacing is referred to as a single technique, it actually contains a number of different elements [61,65,66]. The main elements are taking breaks, alternating activity with rest, alternating between activities that require different body positions or different muscle groups, and alternating between activities of varying difficulty [61,65,67]. Clearly, all these behaviours involve activity interruptions, at least as long as the alternating occurs before the activity is completed. The aim of these behaviours, and of activity pacing in general, is to increase patient functioning by restoring the behavioural pattern of extreme levels of activity fluctuation that is characterized by periods of overactivity followed by "crashes" [66,68,69].

In general, the current literature does not support the position that activity pacing is effective. A number of cross-sectional studies suggests an association of activity pacing with negative outcomes, such as higher pain intensity, physical disability, and depression [70–75]. These findings are counter-intuitive, especially given the broad use of activity pacing. However, the correlational nature of this research and the lack of information regarding the exact operationalization of activity pacing preclude the drawing of conclusions regarding causality. Indeed, it is entirely probable that people experiencing more severe symptoms make more use of activity pacing [75]. To a large degree, cross-sectional studies may reflect this association.

Fortunately, there are some well-controlled intervention studies as well. A large randomized controlled trial showed that an activity pacing intervention was not a useful addition to standard treatment for chronic fatigue syndrome as it did not improve fatigue and physical functioning [76]. On the contrary, it appeared to lead to higher physical deterioration compared to other psychological treatments [77]. More encouraging results come from a small study in osteoarthritis patients. That study showed that a tailored pacing intervention was more effective in reducing self-reported joint stiffness [78] and interference of fatigue with daily activities than a general pacing intervention [79]. Disappointingly, though, these findings were not replicated by a follow-up randomized controlled trial which additionally showed that neither the general nor the tailored activity pacing intervention was superior to treatment as usual [80]. Other ongoing trials (e.g., [81]) are needed and may increase our understanding of the effectiveness of activity pacing.

In sum, the literature on activity pacing and its relation to various outcomes is steadily growing, and suggests that activity pacing is less effective than initially thought. Nevertheless, this literature does not inform us *specifically about the effects of activity interruptions* as these occur within the context of "activity pacing" as a treatment package. Evaluating the effectiveness of a treatment package is important, but it tells us little about the role of each of its components or about the underlying mechanisms of change [82,83]. Therefore, research findings on activity pacing presumably refer not only to activity interruptions, but also to the other elements that constitute it. Confusingly, these may even include opposing behaviours such as "slowing down" and "speeding up" [65]. Given that these elements have not been separately addressed in research, it is not clear to what extent the findings on activity pacing also apply on each specific component, in particular activity interruptions.

An additional reason for the lack of clarity regarding the effects of interruptions may relate to the various ways that they are operationalized within the context of activity pacing. First, activity pacing is used to refer both to the intuitive attempts of (chronic) pain patients to regulate their activity ("naturalistic pacing" [75]) as well as to specific techniques learned within the context of treatment ("programmatic pacing" [75]). Naturalistic and programmatic pacing may differ in operationalization and outcomes [75]. Second, within programmatic activity pacing there are two main theoretical approaches, which result in different and, often conflicting operationalizations (for an elaborate discussion, see [65]). As regards break-taking behaviour, which is our focus here, the main difference between the different approaches refers to the cues that precede the breaks.

The first approach to the operationalization of activity pacing stems from the operant learning theory, which posits that behaviour change will come as a result of changing environmental contingencies [84]. Applied to chronic pain management, this theory assumes that the frequency of desired behaviours (e.g., being active) will be increased if these behaviours are followed by desired outcomes (e.g., successful achievement of a goal or the pleasant feeling of rest), and not followed by undesired outcomes (e.g., pain increase) [85,86]. Thus, the operant learning approach to activity pacing dictates that patients take breaks when they reach a pre-specified activity goal (e.g., walk for a certain number of minutes) in order to reinforce activity [65,85–87]. On the contrary, breaks taken in response to symptoms (such as pain or fatigue) are predicted to reinforce illness behaviours and inactivity, and are thus advised against [65,85–87]. The second approach to activity pacing stems from the idea that every person has a certain level of energy to expend, in analogy with a battery. Given that this level of energy cannot be exceeded, the focus is on distributing it throughout the day in a way that allows the performance of activities [65]. This approach makes no assumptions about and sets no restrictions on the contingency of the breaks. Rather, it allows patients to interrupt their activity in response to pain or other symptoms [65].

Given that the various differences between the two approaches to activity pacing have been discussed in detail elsewhere [65], we will not present an exhaustive review. What we wish to highlight, however, is that taking breaks within the context of activity pacing – and, more broadly, within the context of pain – is *not* a fixed behaviour but, rather, a behaviour that can have different characteristics. As mentioned earlier, different interruption characteristics may have differential effects. The theoretical analysis that was briefly presented above [4] may serve as a framework for the investigation of different characteristics of an interruption by pain, such as whether an interruption is contingent on the achievement of a part of the activity, as dictated by the operant learning approach to activity pacing, or whether it is contingent on pain, as suggested by the energy conservation approach to activity pacing. Other factors, such as the type of activity performed during the interruption (e.g. an alternative physical or cognitive activity, or plain rest), the degree of similarity of the interruption activity to the interrupted activity, the length of the interruption, etc., may also moderate the effects of activity interruptions in the context of pain. Experimental research, which allows the manipulation of such factors, may help in that direction. Clearly defining the characteristics of activity interruptions will enhance the understanding of their effects and potentially facilitate the improvement of their clinical use. Inspired by the interruption literature from other research fields, we now make specific suggestions on how to manage the effects of activity interruptions in the context of pain.

Interruption management: From the workplace to pain

Irrespective of whether pain-relevant interruptions are more or less disruptive than pain-irrelevant interruptions, activity interruptions within the context of pain have negative consequences [36,39,40]. Thus, a likely treatment objective for people with persistent pain problems is to limit the disruptiveness of such interruptions. Below, we make some suggestions on how to decrease the negative effects of activity interruptions in the context of pain. However, because research on interruption management in the context of pain is missing, our suggestions are inspired by contemporary knowledge about interruptions from the field of human factors, ergonomics, and computer-human interaction. Based on knowledge from these fields, we specifically suggest that the negative consequences of activity interruptions by pain may be mitigated by (1) improving the timing of the interruption, (2) creating retrieval cues for the interrupted task, and (3) rehearsing (the intention to resume and information about) the interrupted task. We now elaborate on each suggestion separately.

Improving interruption timing. Theoretical accounts of task interruptions from outside the field of pain highlight the role of memory processes in the successful resumption of interrupted activities [31,34,35,88–90]. One way to limit the probability of a memory lapse is to decrease the amount of information to be encoded and stored in memory. In the case of interruptions, this can be achieved by wrapping up a meaningful part of the activity before interrupting it [34]. For example, taking a break from reading a book in order to stand up for some back-stretching exercises may be less devastating if the break is taken upon finishing a book chapter. Indeed, interruption timing is a moderator of interruption effects, with interruptions occurring at the so-called "task boundaries" being experienced as less frustrating and less disruptive [91–93]. Task boundaries differ for each task and may be defined in various ways. When cooking a meal, for example, a meaningful task boundary may be chopping up only the vegetables, or both the vegetables and the meat. Further, in some continuous tasks there are no clear and meaningful task boundaries. The person may then set their own meaningful boundary, such as ironing ten items of clothing before taking a break. Interrupting activities on meaningful boundaries parallels the goal-contingent breaks suggested by the operant learning approach to activity pacing [65]. In that respect, activities interspersed with goal-contingent breaks may not only be reinforced [85,86], but they may also be resumed more successfully because of imposing lower demands on memory, and be experienced as less negative than activities interrupted by (symptom-contingent) breaks that do not take place at task boundaries.

Creating retrieval cues for the interrupted task. Increasing the accessibility of the interrupted activity in memory is expected to help improve its subsequent resumption (e.g. [31]). To achieve this, the activity may be associated with an environmental cue that will be encountered after the interruption [34,94,95] and will thus increase the probability that this memory will be retrieved. For example, a pain patient who takes a break from reading a book in order to stand up and walk, will be able to resume faster and more easily if they mark the last paragraph they read (cf. [96]). For such a cue to be useful, it is important that neither the cue itself [95] nor the state of the interrupted activity [56] change during the interruption. The effectiveness of the retrieval cue is likely moderated by various characteristics, such as how difficult it is to miss [45]. A special case of a retrieval cue may be the verbal association of the end of the interruption with the resumption of the interrupted activity. For example, one may make a specific plan such as “when I have rested for 10 minutes, I will continue working in the garden”. Such verbal associations, called “implementation intentions” [97], are consistently found to lead to increased memory for and performance of intended actions [98,99].

Rehearsing (the intention to resume and information about) the interrupted task. An other way of strengthening the memory of the interrupted activity is to regularly rehearse the intention to later resume that activity and the information about the state where the activity was left off [34,41]. For example, a worker with chronic pain who briefly leaves their desk to go for a walk may resume the interrupted task faster and easier if, during the walk, they regularly think back to the interrupted activity. Depending on factors such as the difficulty of the activity performed during the break, rehearsal can take place at various time points and to a different degree.

The suggestions listed here are not mutually exclusive, but can be used in combinations. For example, a person may take a break at a task boundary and then create a retrieval cue indicating the next part of the task to be performed. We expect that these suggestions will be easier to implement if the person takes some time right before the interruption to improve encoding [34,35,100]. Intentionally taking time to prepare for the interruption may decrease its negative consequences. Mitigating the negative effects of interruptions by pain may also have positive emotional effects, as patients may feel lower frustration and higher sense of control when they are carrying out meaningful activities. In addition, easier task resumption may also increase motivation to resume an interrupted activity, and therefore also the probability that the activity will be successfully completed.

Nevertheless, the suggestions sketched out here are based on the interruption literature from outside the field of pain, and should thus also be investigated and confirmed by future pain research. The usefulness of these techniques in the field of pain may be evaluated with experimental studies that manipulate the variables in question. For example, carefully observing performance in an activity that is interrupted by pain at different points (e.g., at task boundaries that are inherently meaningful, at task boundaries set by the person, or before a task boundary is reached), will indicate whether improving interruption timing is a technique that facilitates performance. Ideally, results will be corroborated by clinical studies, in which, for example, the interruption pattern of people with persistent pain will be followed (e.g. with actigraphy and experience sampling) and their subsequent task performance will be assessed. In general, even though suggestions for interruption management in the field of pain may be made on the basis of knowledge from other research areas, further research is warranted to confirm that these interruption management techniques are also effective in the case of activity interruptions by pain.

Conclusions and future perspectives

We highlighted the function of activity interruptions by pain as a natural response to pain and as an ingredient of activity pacing, thus building a case for a systematic study of their precise effects. The current evidence of experimental studies indicates that activity interruptions by pain impair the performance of the interrupted activity, though not necessarily to a larger extent than interruptions by non-painful stimuli [38–40]. Furthermore, people seem to adapt the way they perform activities that are interrupted by pain, for example in terms of their persistence in the interrupted activity [37] or of the distribution of their time to different activities over the day [36]. As of yet, however, there are no indications that people perform activities interrupted by pain differently than activities interrupted by non-pain (e.g., in terms of the time spent on interruptions [38]). Nevertheless, the effects of activity interruptions by pain may be moderated by various characteristics related to the interruption (e.g., its duration; cf. [101]), the interrupted activity (e.g., its importance), and the person (e.g., working memory capacity; cf. [101]) [4]. Well-controlled experiments that allow the manipulation of such characteristics will advance our understanding of interruptions by pain, and may help to tailor or otherwise advance the use of activity interruptions in chronic pain interventions.

Besides the investigation of moderating factors, the consideration of different outcome measures may also increase our understanding of interruptions by pain. For people with persistent pain problems there are many relevant outcomes; for example, pain intensity, probability to (remember to) resume the interrupted activity (cf. [35]), quality of activity performance, motivation to perform the activity, and experienced emotions. Research from other fields shows that interruptions may have different effects on different outcomes. For example, interruptions may increase stress and frustration [52,102] even if they do not impair performance [5,6]. The same may be the case in chronic pain where interruptions may facilitate pain relief but at the same time impair activity performance, and hence increase stress and frustration. Advancing our knowledge on the effects of interruptions on different outcomes may allow patients and therapists to make informed decisions about using activity interruptions in the context of (chronic) pain management.

Disclosures

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